

# Unification and Improvements to Guidance for National Weather Service Tropical Cyclone Wind and Storm Surge Hazard Products

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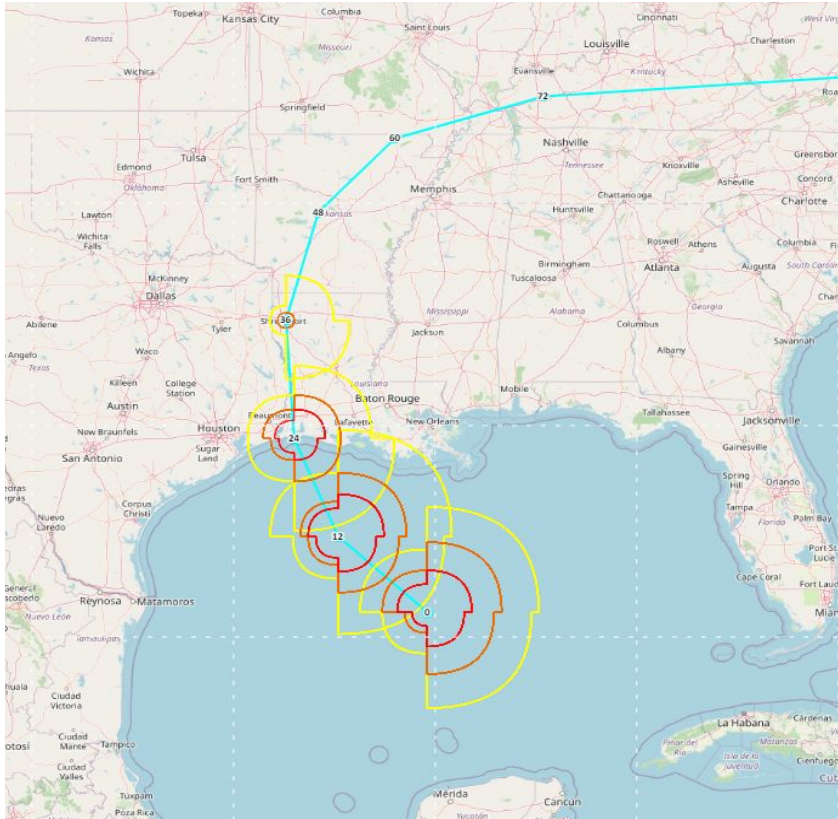
# Project Goals

Update WTCM surface wind model	Update the WTCM hurricane surface wind model by expanding its developmental database, recalibrating its algorithm, and adding wind gusts to the output
Generalize wind speed probabilities	Generalize the National Hurricane Center wind speed probability (WSP) model to use ensembles of WTCM surface wind fields
Create new wind exceedance graphic	Create a wind exceedance output graphic from the WSP model that is analogous to the NHC potential storm surge flooding map

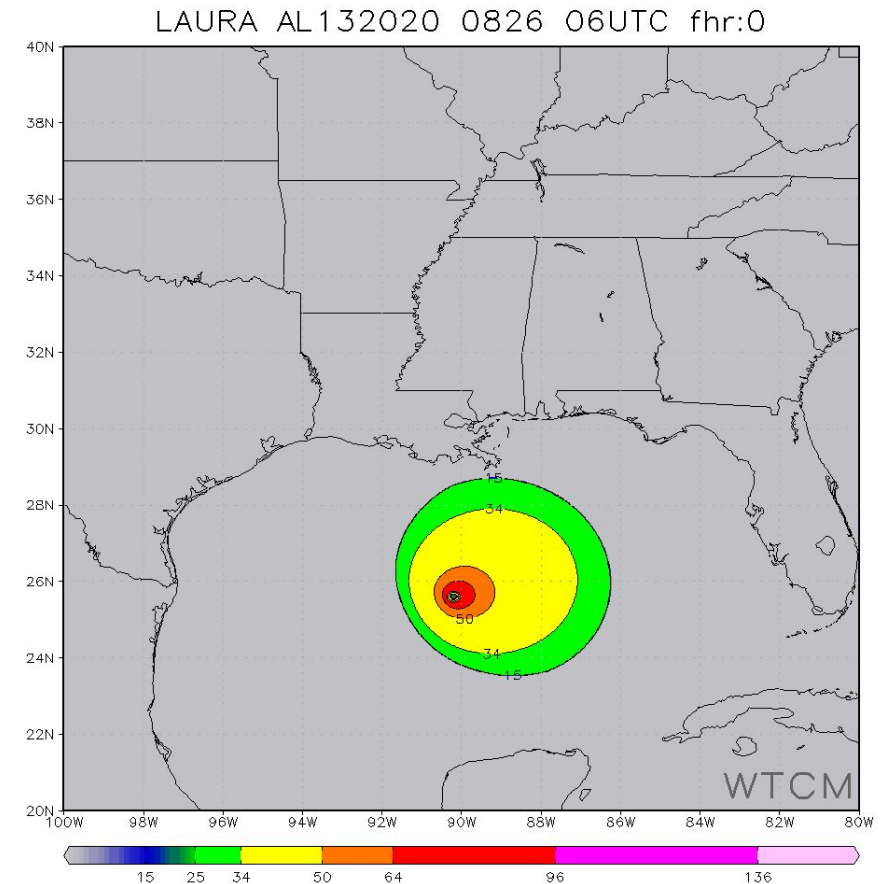
# WTCM Overview

- WFOs, TAFB and OPC require 2-D gridded surface wind field at hourly intervals to 7 days consistent with the NHC TCM text product
- AWIPS TCM wind tool
  - Very simplified, especially over land
- Gridded-TCM (GTCM) prototype developed by Pablo Santos and Craig Mattocks 2017-2018
  - Parametric vortex and land surface wind reduction
- Open-source version developed using extension of NHC Wind Speed Probability Model (WTCM)
  - 2020 demo – v1.4.0
  - 2021 demo – v1.5.0 (thru Aug 10), v1.6.1 (since Aug 11)

# WTCM - Example Laura 2020

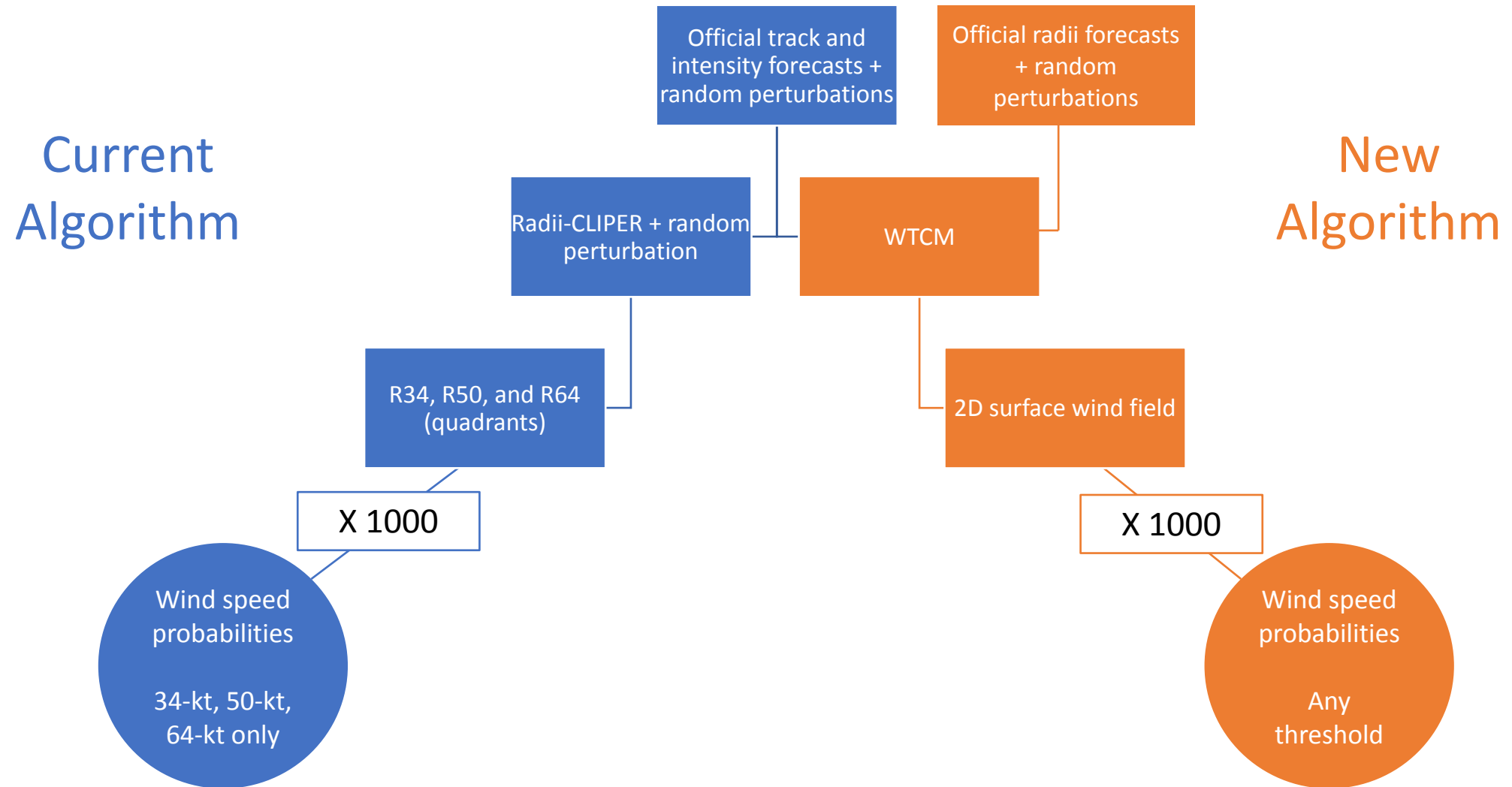


TCM track, intensity, wind

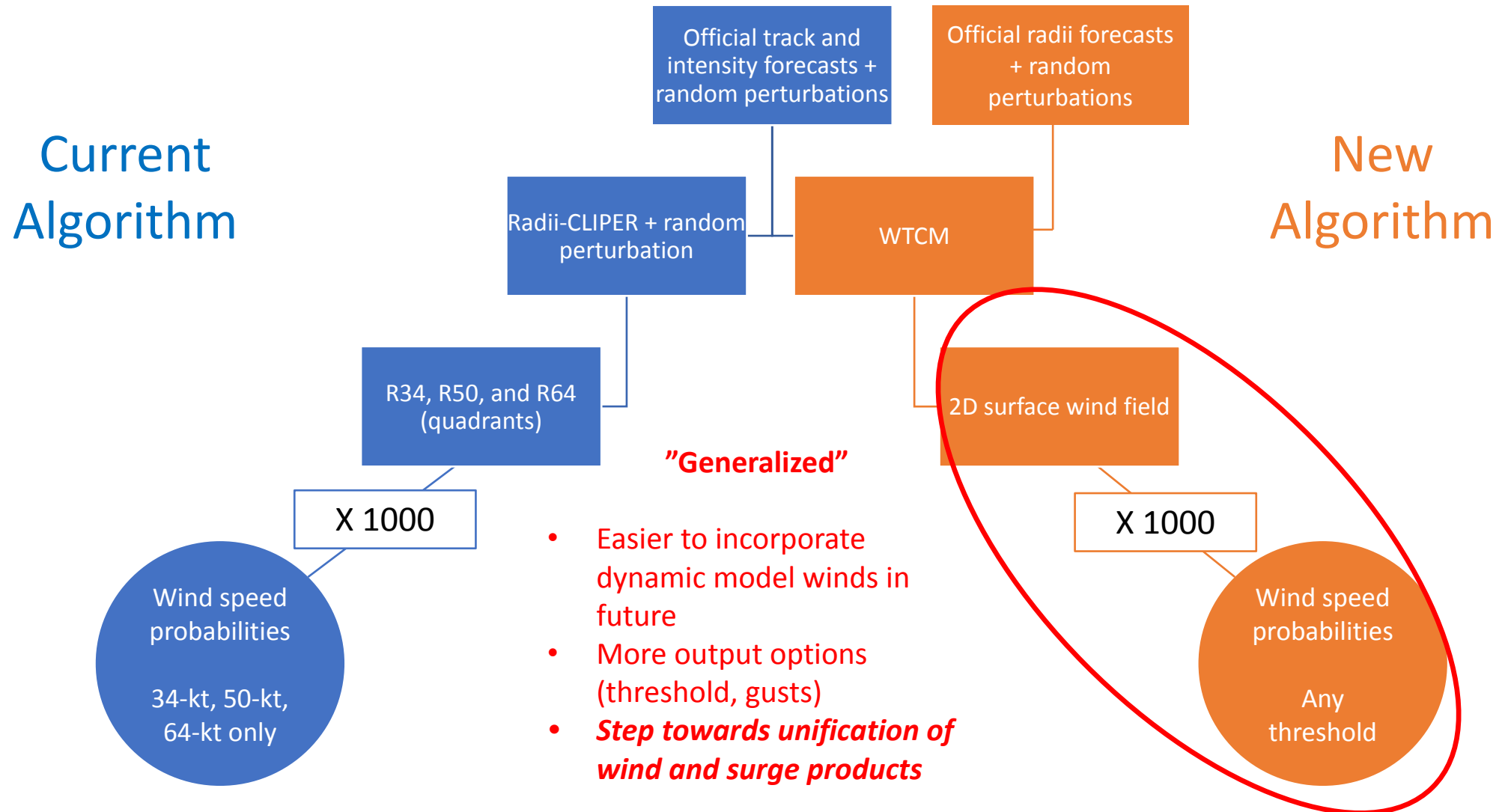


Hourly 2-D surface wind field

# Incorporating WTCM into the WSP model



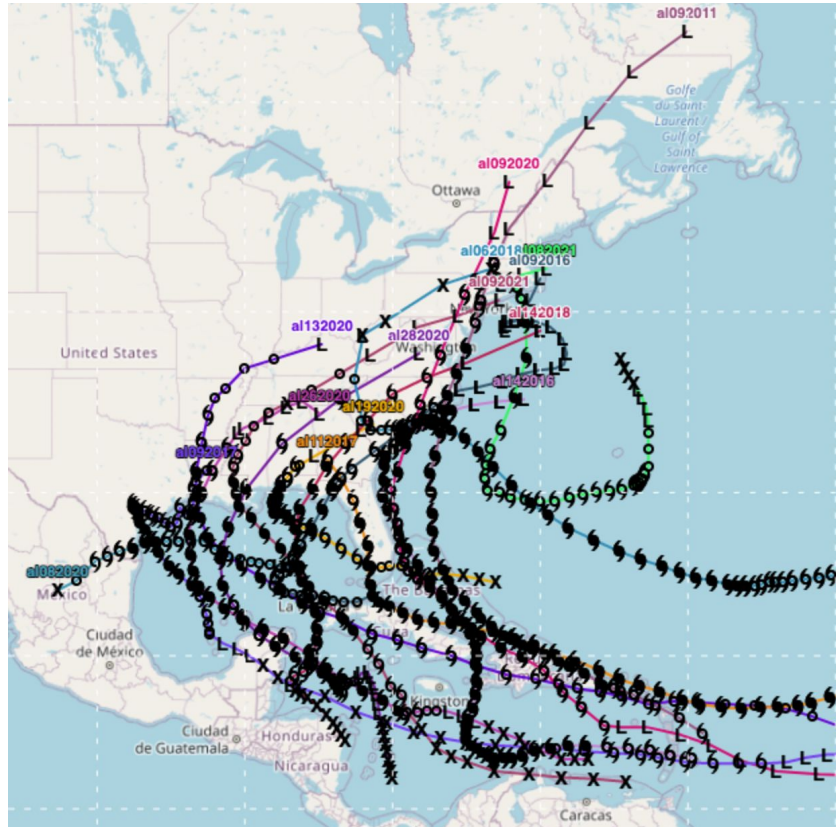
# Incorporating WTCM into the WSP model



# Goal 1 – Update WTCM

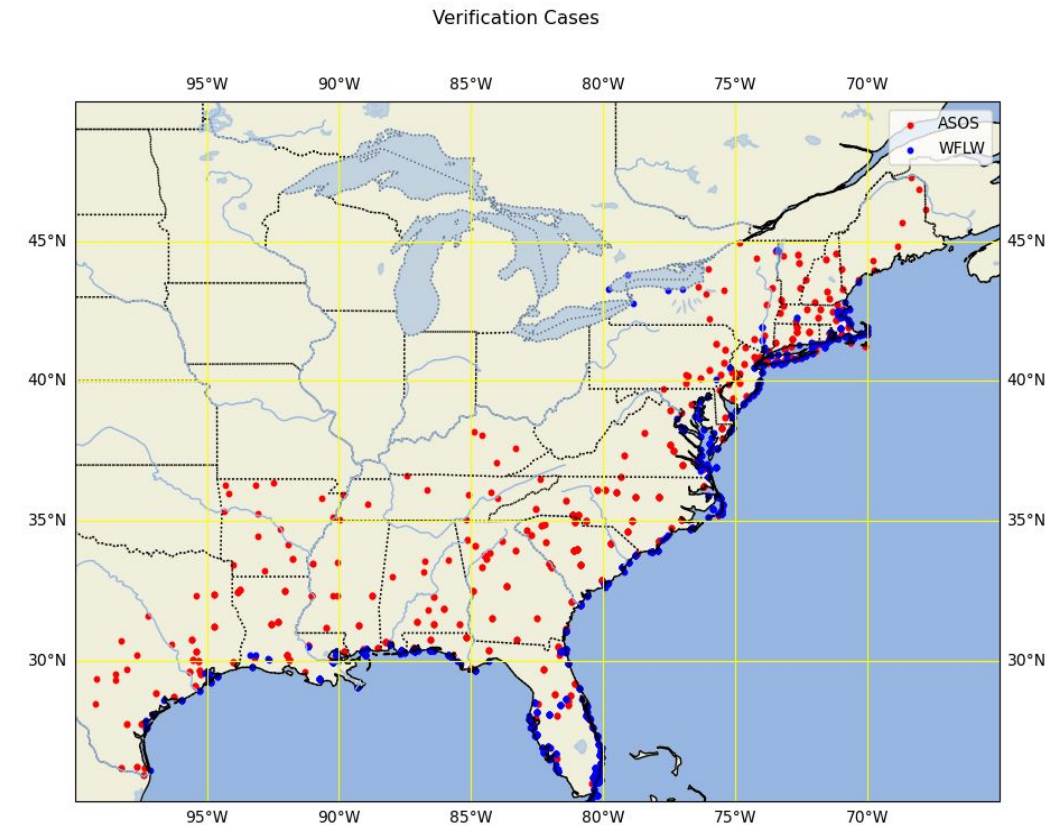


# Expanded WTCM Database



## 15 TCs in the verification sample

Irene 2011, Hermine, Matthew 2016, Harvey, Irma 2017, Florence, Michael 2018, Hanna, Isaias, Laura, Sally, Delta, Zeta 2020, Henri, Ida 2021

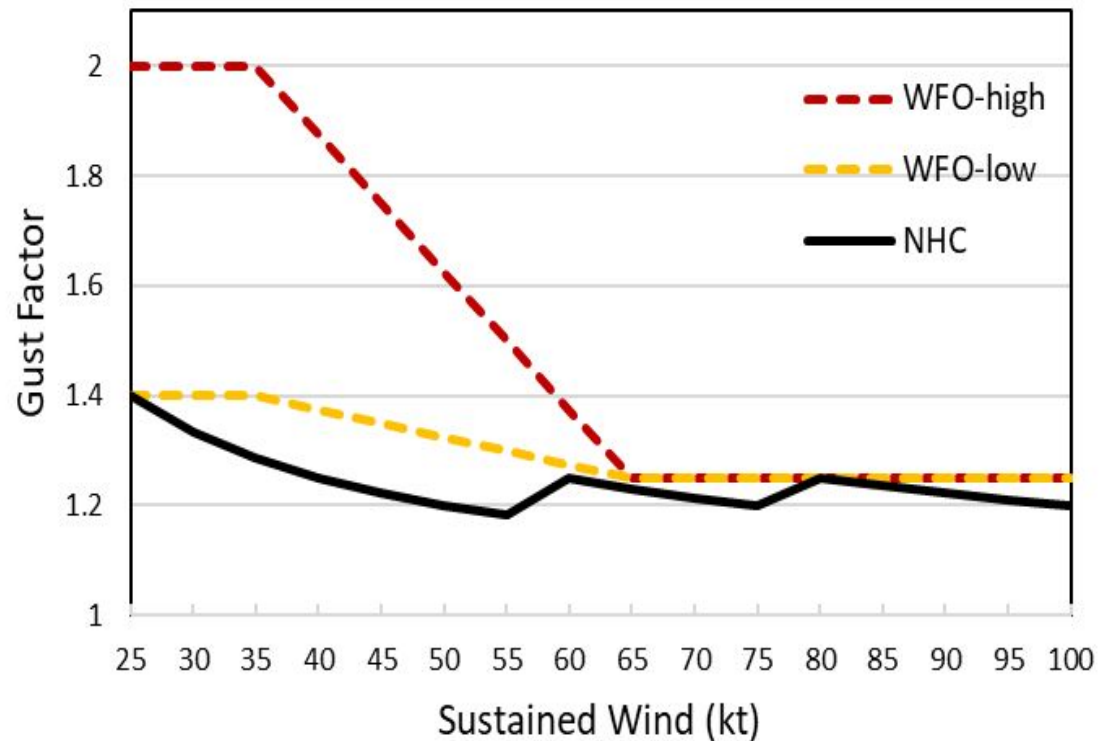


## ASOS and WeatherFlow Station Locations

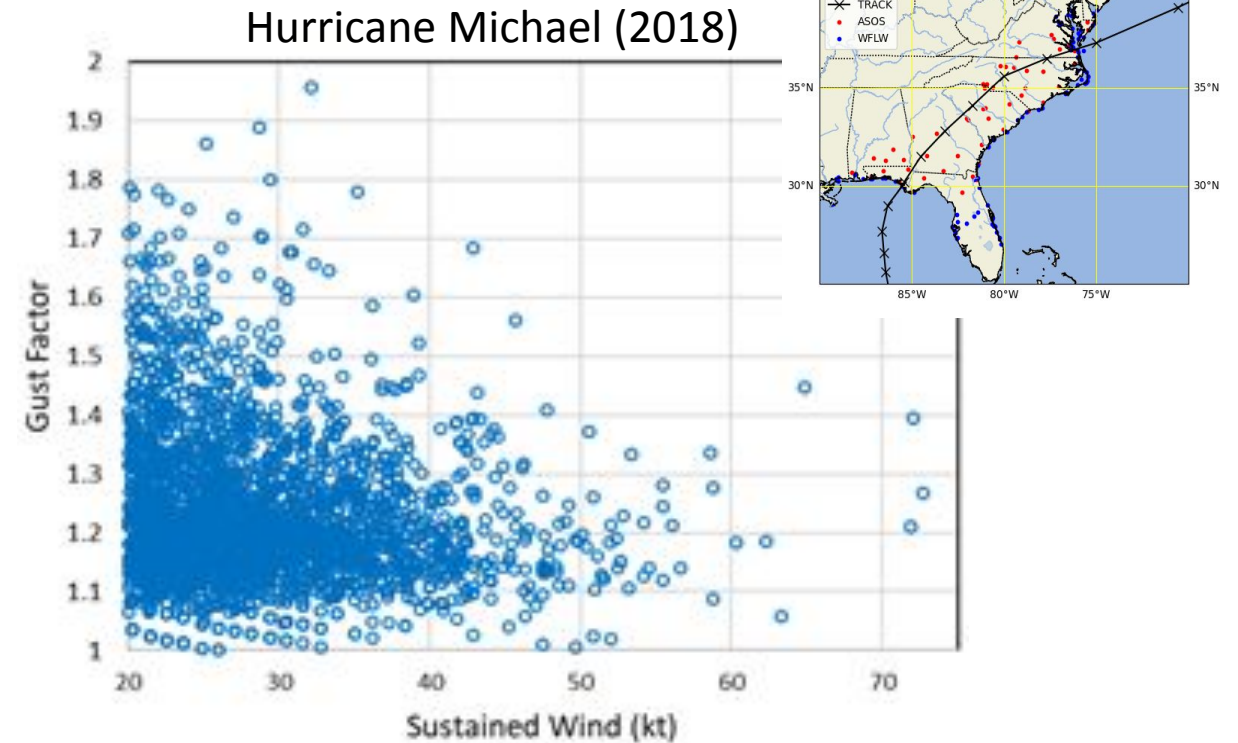
WTCM runs with best track input and 15 min time step  
55,162 observation-model match ups  
30,797 land exposure points



# Develop WTCM Gust Parameterization



Current



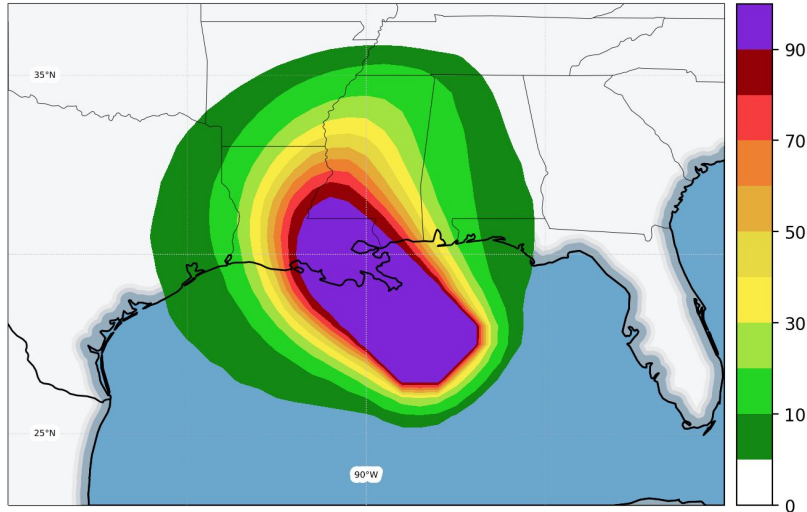
Future Research

# Goal 2 – Generalize WSP model to include WTCM

# 0-120 hr 34 kt Cumulative Probs – Ida Case

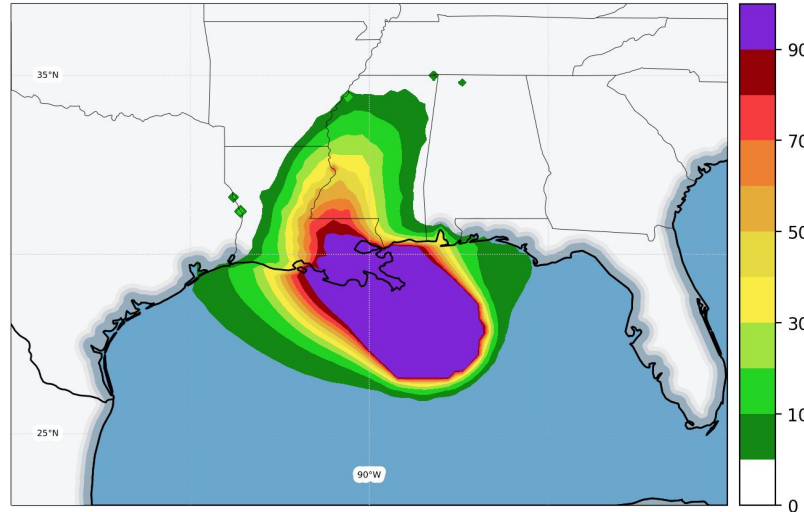
## Current

34.0 kt Wind Speed Probabilities  
For the 120 hours (5.0 days) from 2021-08-29 06:00:00



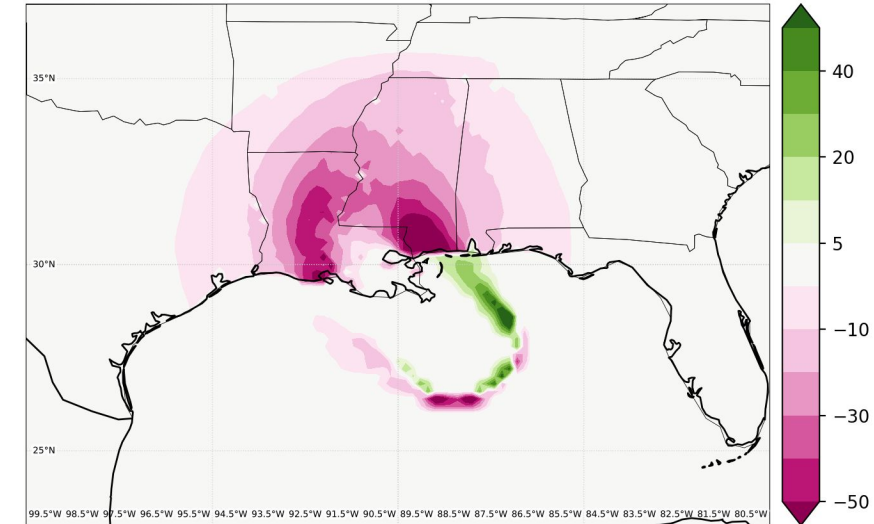
## New WTCM-based

34 kt Wind Speed Probabilities  
For the 72 hours (3.0 days) from 2021-08-29 06:00:00



## New - Current

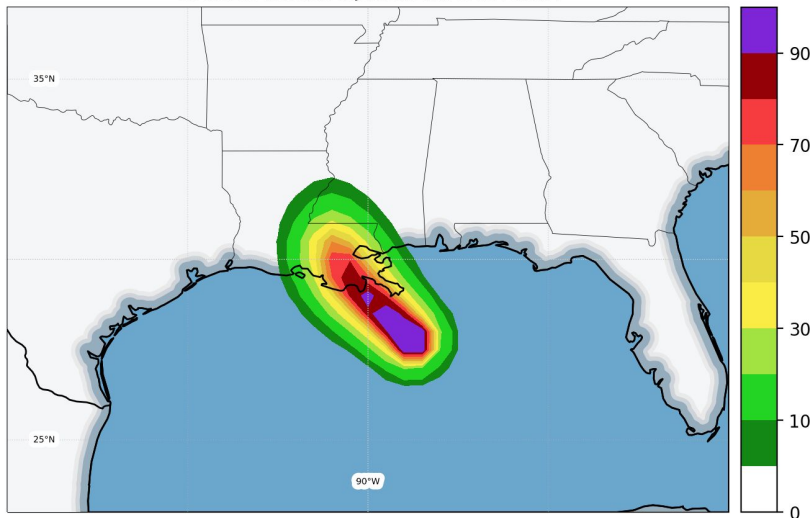
2021-08-29 06:00:00 - Difference in Probability of Wind Speed > 34kt



# 0-120 hr 64 kt Cumulative Probs – Ida Case

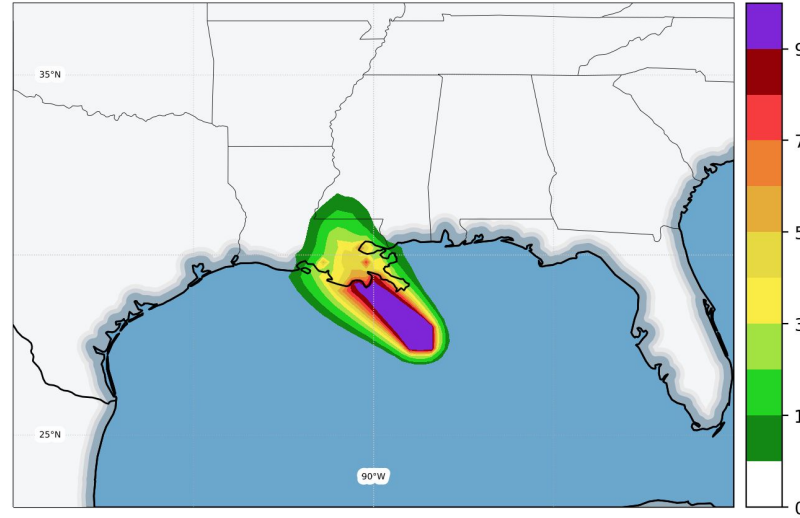
## Current

64.0 kt Wind Speed Probabilities  
For the 120 hours (5.0 days) from 2021-08-29 06:00:00



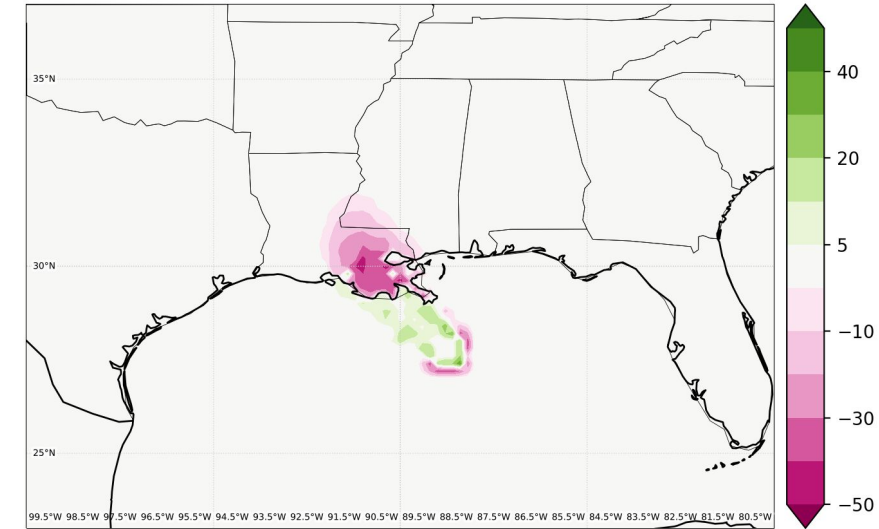
## New WTCM-based

64 kt Wind Speed Probabilities  
For the 72 hours (3.0 days) from 2021-08-29 06:00:00



## New - Current

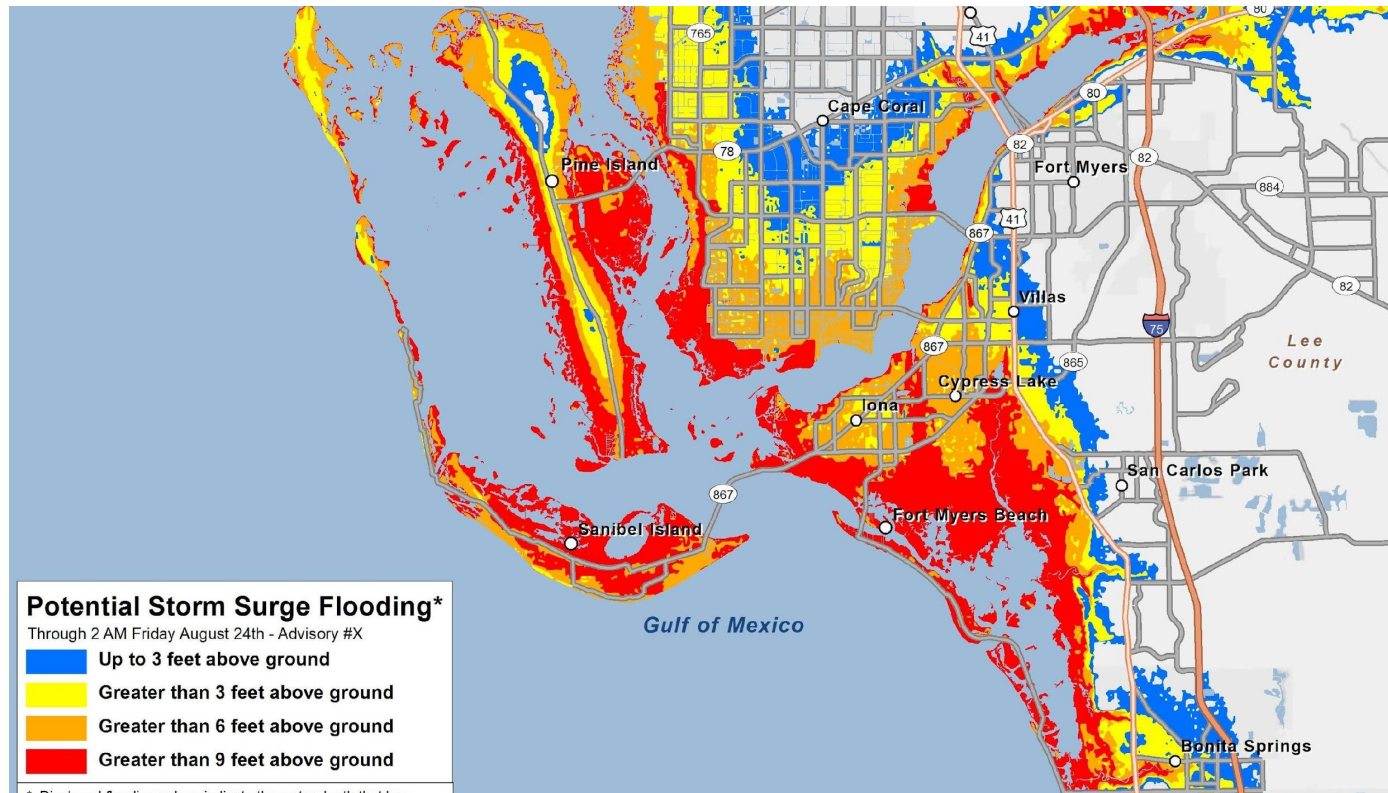
2021-08-29 06:00:00 - Difference in Probability of Wind Speed > 64kt



- If implemented, will be a BIG CHANGE – WSPs reduced substantially (correctly) over land
- Closely coordinating with the NWS Tropical Roadmap Team and NHC
- Potential H.O.T. Testbed Experiment(s) to assess impacts of changes on forecasters and partners (emergency managers, broadcast meteorologists, etc)

# Goal 3: Create New Wind Exceedance Graphic

# Step toward unifying wind and surge messaging - graphics

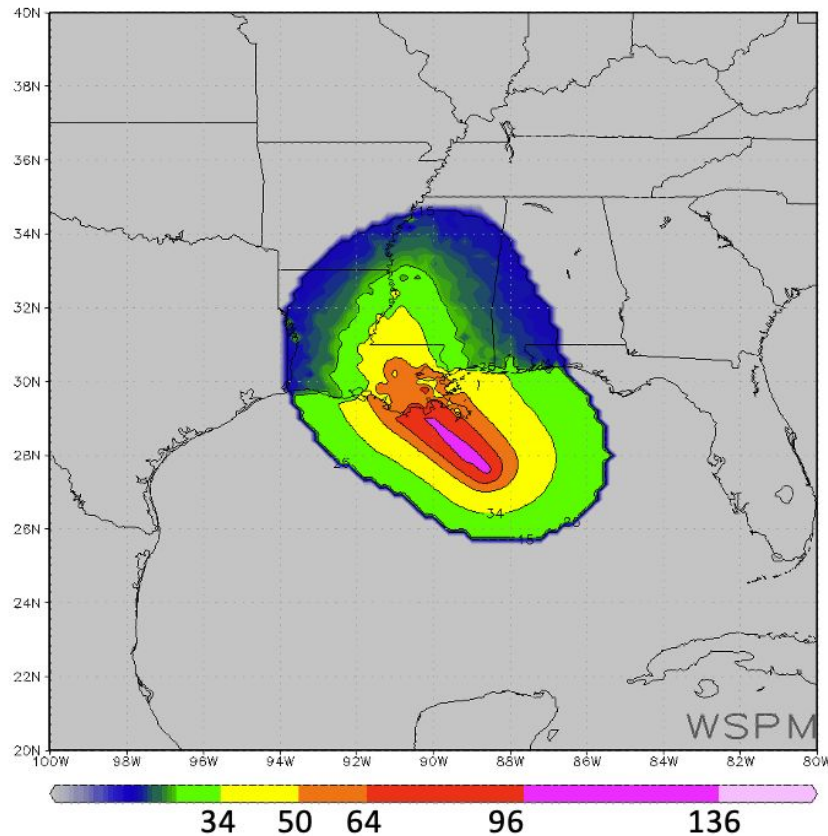


- Based on a 1 in 10 likelihood
- Represents a reasonable worst-case scenario
- Extensive social science testing and input



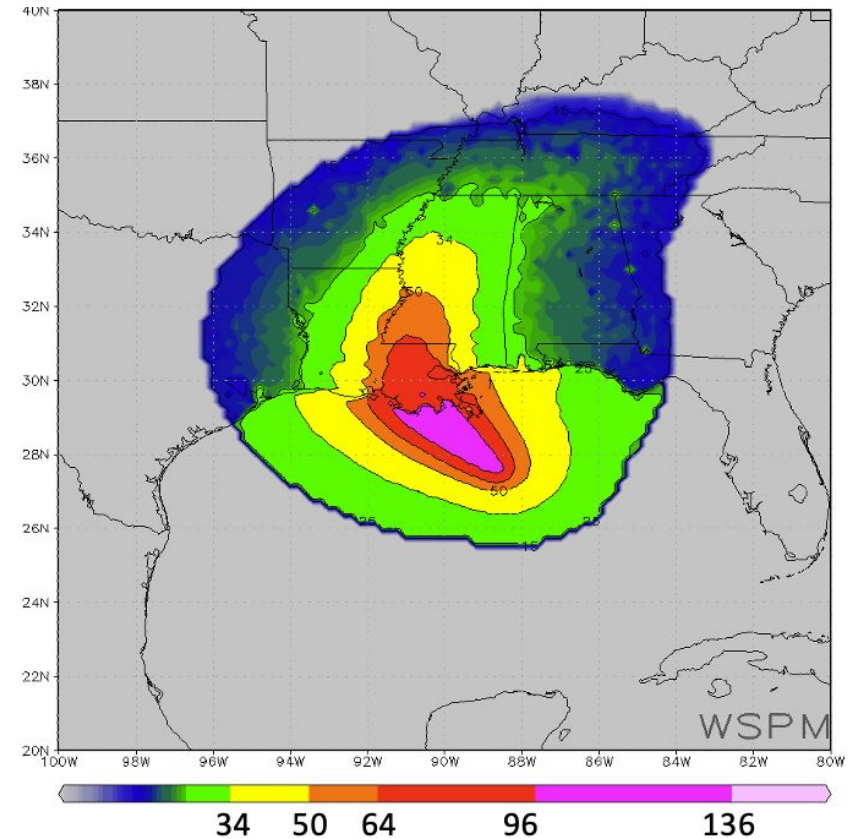
# New Output - Wind Exceedance

50<sup>th</sup> percentile



“Most Likely”

10<sup>th</sup> percentile



“Reasonable Worst Case”

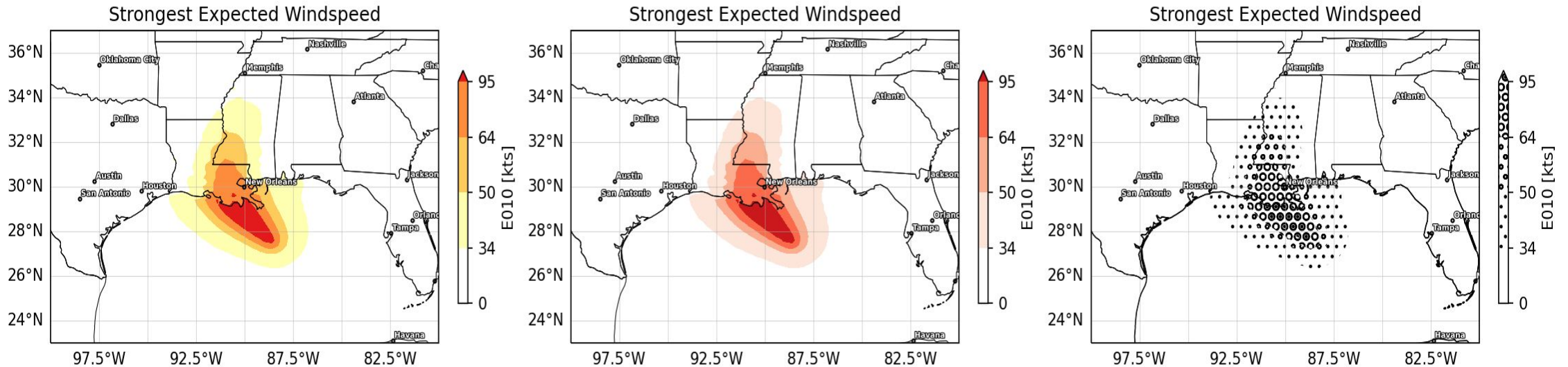
# Collaboration with social scientists

- When we develop products with social scientists, everyone benefits.
  - By involving from the start, we can see how products are interpreted as they are being used, instead of solely after they have already been released.
- Collaborating with Zoey Rosen and Marilee Long from the CSU Dept. of Journalism and Media Communication (CIRA base funded)
- Important considerations for product development
  - Color Choice
  - Salience and Attention
  - Probability Language



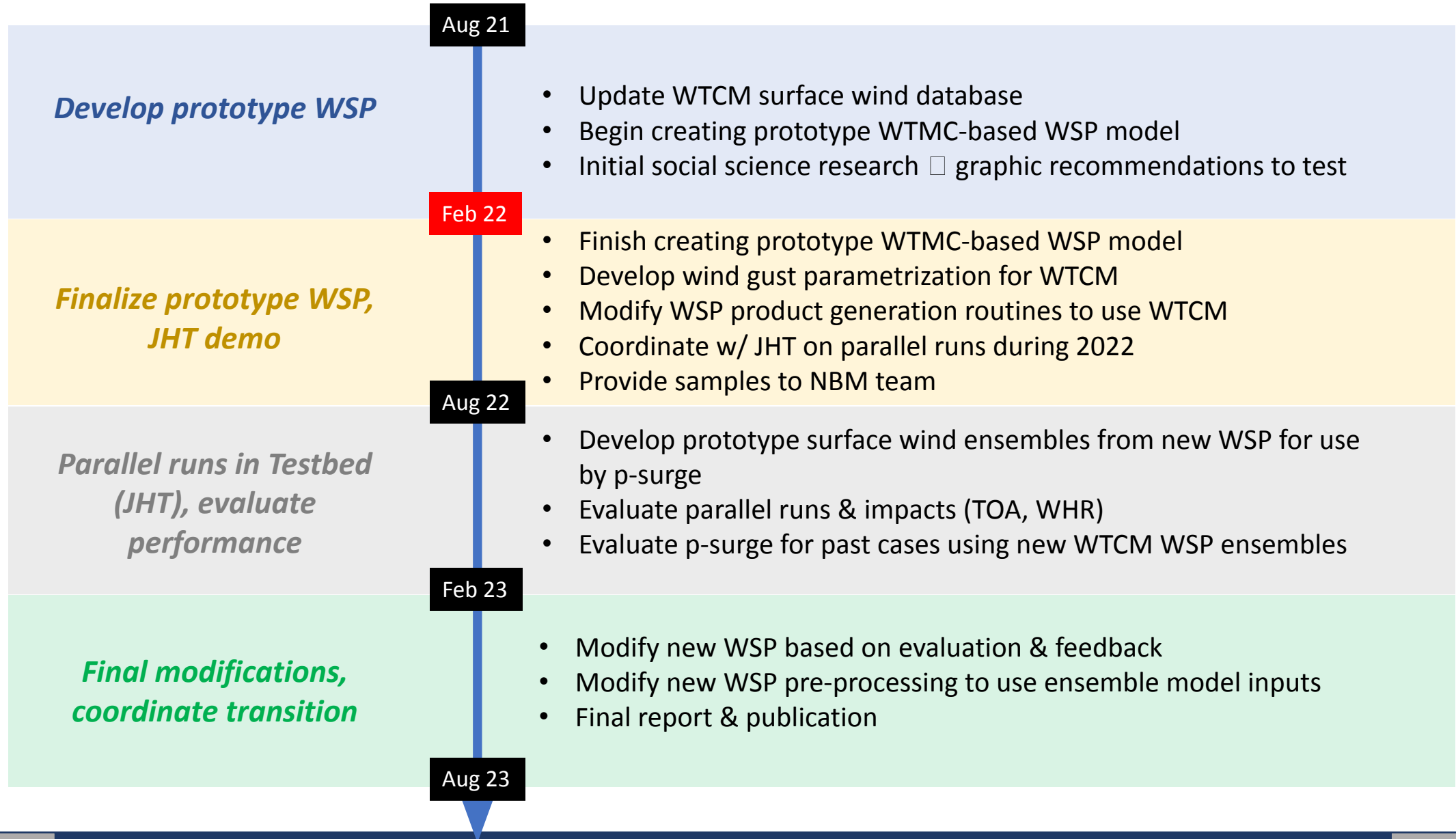
# Initial recommendations

- Use a colorblind-friendly color scheme that is in line with other emergency graphics literature
- Add landmarks to map products
- Improve probability language in titles



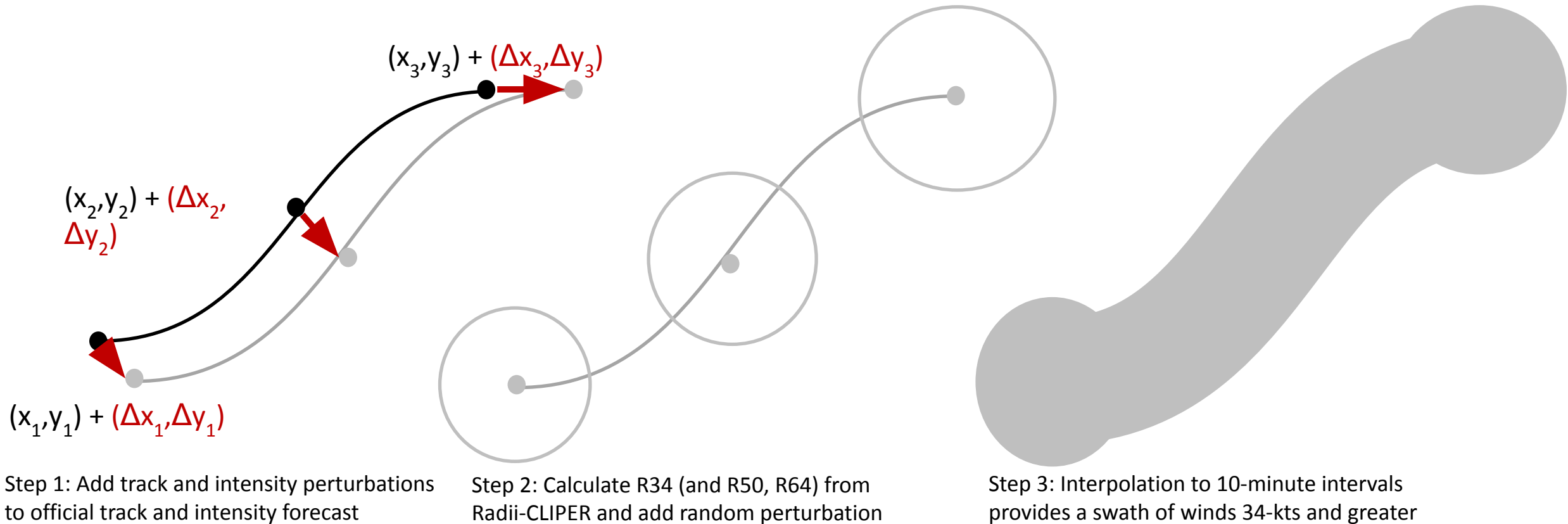
- Potential H.O.T. Testbed Experiment(s) to evaluate new wind exceedance graphics with forecasters and partners (emergency managers, broadcast meteorologists, etc)

# Major Milestones / Timeline



# Extra Slides

# WSP Algorithm Schematic (Simple)



	Starting value	Perturbation
Track and intensity	NHC official forecast	Random sampling from last 5 years of official forecast errors
R34, R50, R64	Radii-CLIPER	Random sampling from past observed deviations from predicted Radii-CLIPER value



# *Involving Multiple Disciplines From the Beginning*

- **When we develop products *with* social scientists, everyone benefits.**
  - **By involving from the start, we can see how products are interpreted as they are being used, instead of solely after they have already been released.**
- **Social science is NOT as slow as we have thought**
  - **When working *concurrently* as those who code and analyze the data for forecast products, social scientists can develop research questions that best suit the topic and team, which saves time in the long-run.**
  - **All research takes time, but having an interdisciplinary team at all stages of product development (e.g., designing, implementing, and evaluation) is efficient, inclusive, and can foster more creative and pragmatic products.**

# *Considerations for Product Development*

## **Building Phase**

- **Color Choice**
  - Are the colors we are using colorblind friendly? Have they been used in similar hazard products in the past?
- **Salience and Attention**
  - What are your eyes drawn to in the product? Is this what you want your user to focus on?
- **Probability Language**
  - What are you using? Where is it imposed onto the map?

## **Evaluation Phase**

- **Accuracy of Interpretation**
  - How well do user interpretations match with graph value?
- **Confidence of Use**
  - How comfortable is your intended audience with making decisions based on forecast product?

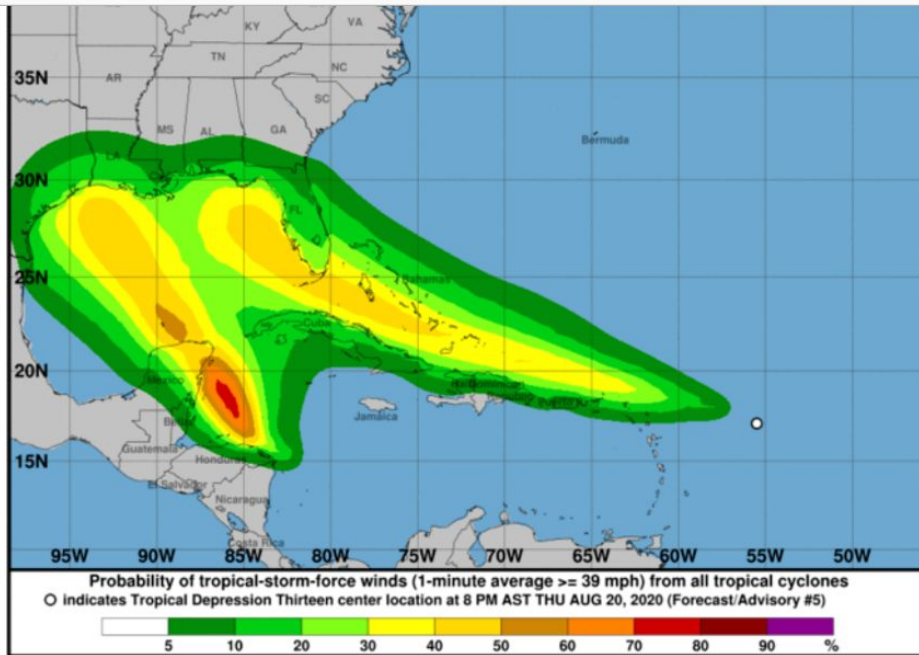
## *Recommended Design Ideas*

- 1. Use a colorblind-friendly color scheme that is in line with other emergency graphics literature**
- 2. Add landmarks to map products**
- 3. Improve probability language in titles**

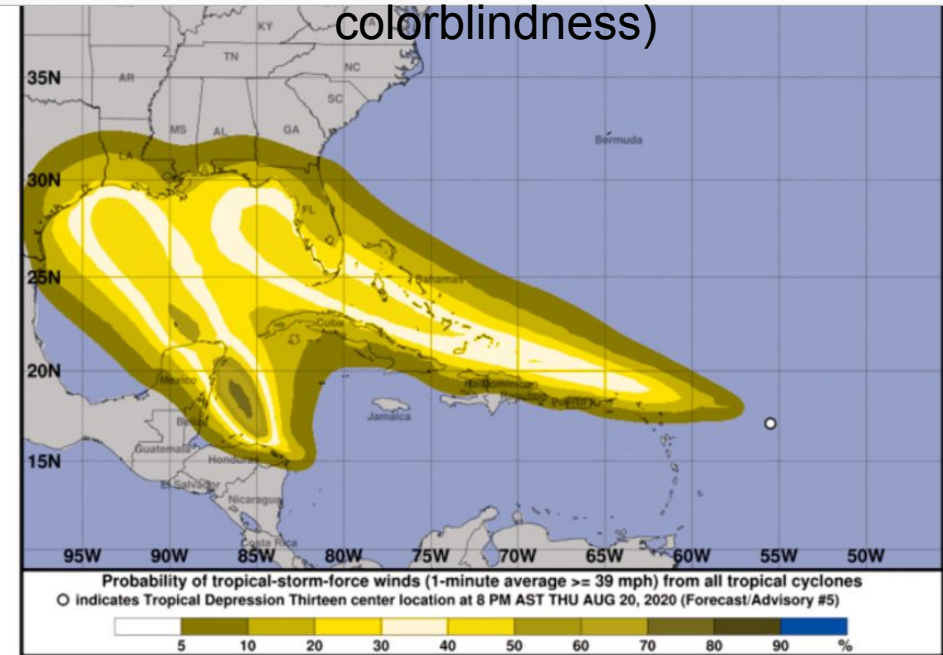
# Color Schemes

The current WSP color scheme is not colorblind-friendly

Current wind speed probability color scheme



As seen for those with protanopia (red-green colorblindness)

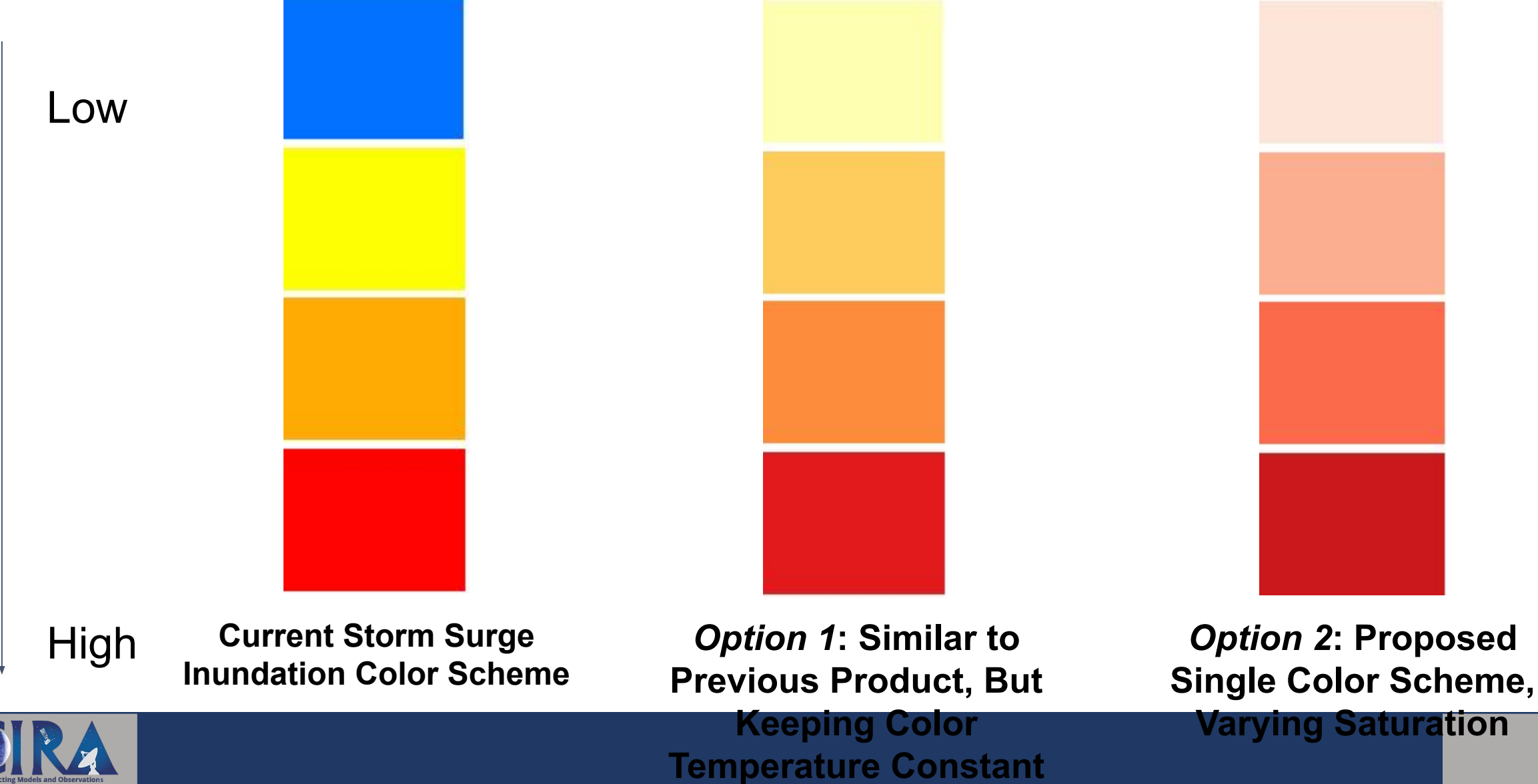


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# Color Schemes



# *Landmarks*

- Localized context for flood maps (Henstra et al, 2019), people are drawn to their own location when viewing maps because of the personal relevance (Lindner et al, 2018)
- Locations usually have primary cartographic position, secondary is certainty of impact (Cheong et al, 2019)
- Example: Major city markers



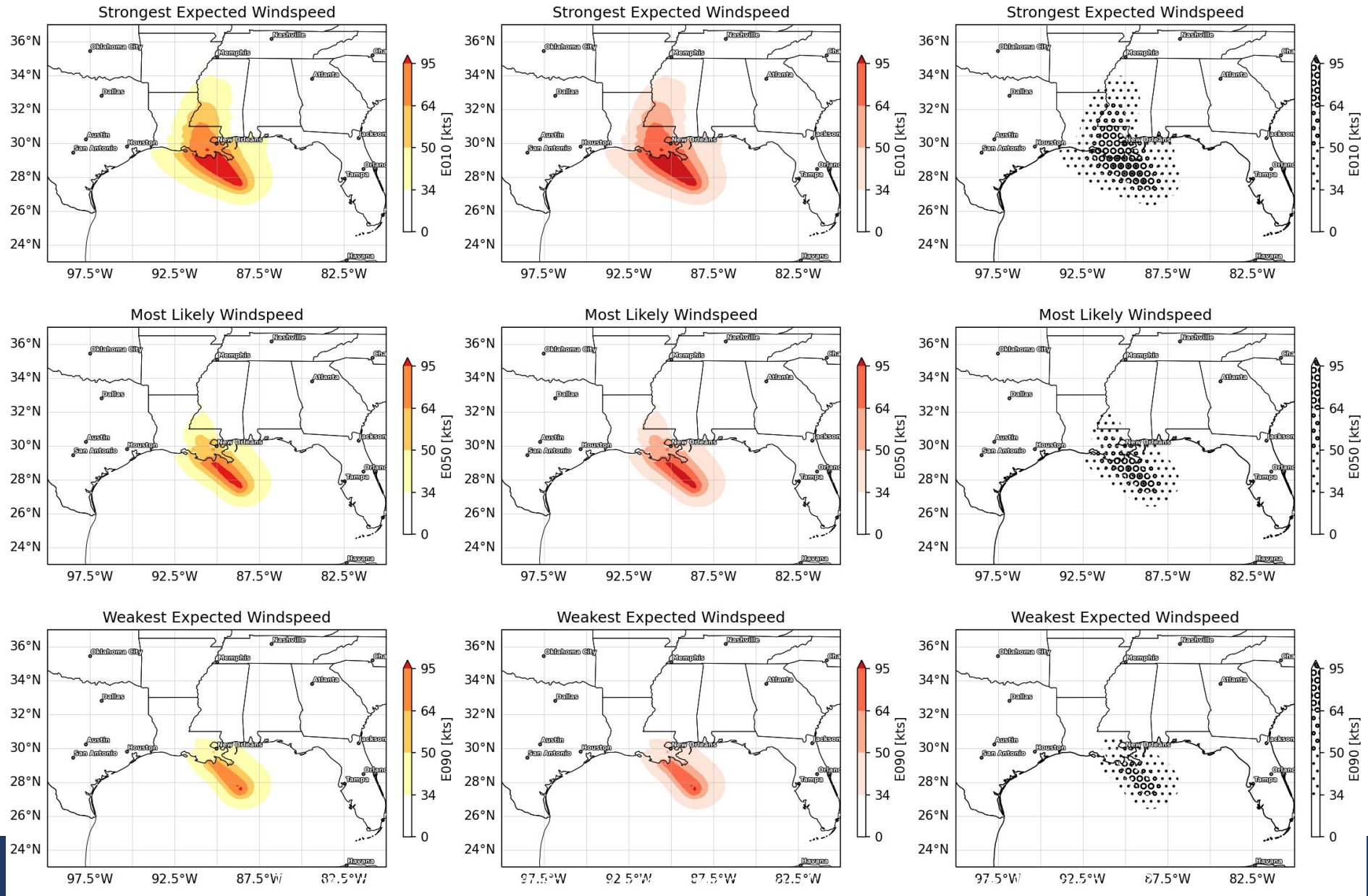
# *Probability Language in Titles*

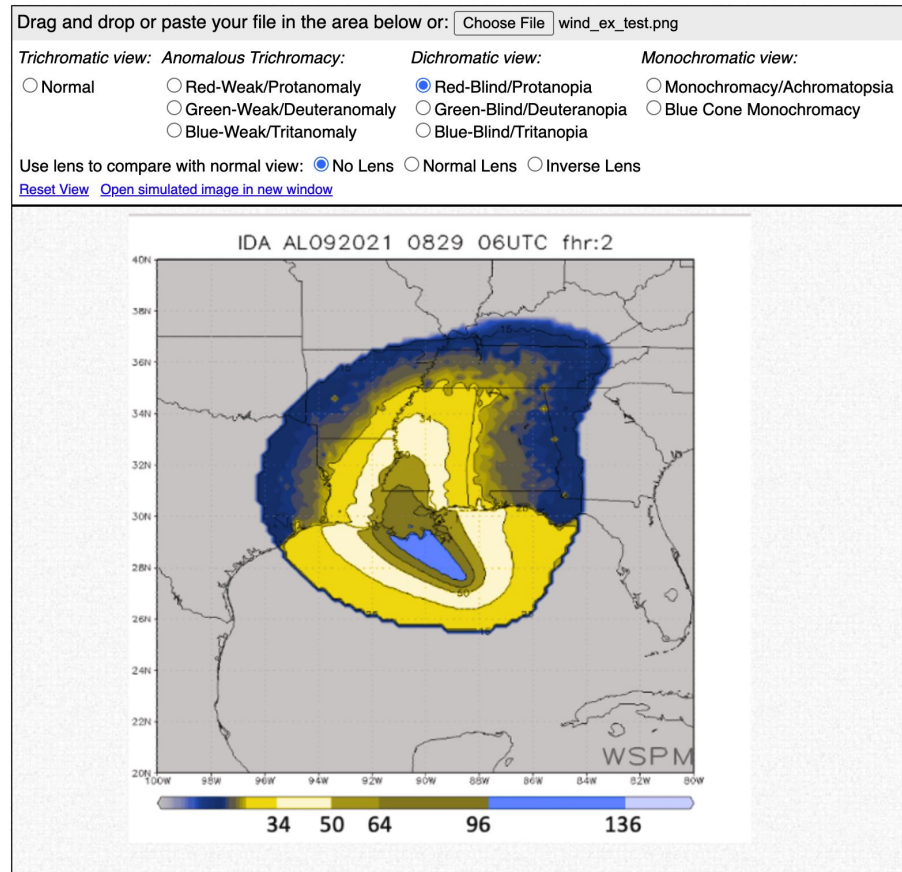
- 0.10 or 10% better conveys forecast uncertainty, but “1 in 10” language provokes higher concern/conveys as riskier (Lindell et al, 2021).
- Using words and numbers together to describe probability is a recommended practice (Rosen et al., 2021; Lenhardt et al., 2020).
  - Replace: Severe thunderstorms are possible this evening.
  - With: Severe thunderstorms are possible (20% to 30% chance) this evening.
- Using modifiers (e.g. “high” or “low”) can aid with interpretation (Rosen et al., 2021; Lenhardt et al., 2020).

# Universal Design

- Universal Design is “the design and composition of an environment so it can be accessed, understood, and used to the greatest extent possible by all people, regardless of their age, size, ability, or disability” ([General Services Administration](#))
- Universal Design is essentially “good” design--making products that are easy to use by the consumer, are appropriate for a wide range of users with different abilities, and communicates information effectively and equitably.
- So, why should we plan to make our products with universal design principles from the start?
  - Besides [being 508 compliant](#), universal design saves costs in the long-term from needing to re-design products, encourages more user engagement with products due to ease of use, and encourages more innovative products overall since it affords multidisciplinary teams an opportunity to work together from the beginning of product development ([General Services Administration](#))

# Product Design Examples – Ida Case





<https://www.color-blindness.com/coblis-color-blindness-simulator/>